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COMPARISONS OF THE UNDERWATER POWER OF EXPLOSIVES IN SMALL CHARGES.

VII. A STUDY OF FACTORS AFFECTING THE POWER OF HBX-1. (U)

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COMPARISONS OF THE UNDERWATER POWER OF EXPLOSIVES IN SMALL CHARGES. VII. A STUDY OF FACTORS AFFECTING THE POWER OF HBX-1. (U)

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ABSTRACT: This report presents the results of a study to determine the cause of the observed decrease in the power of small charges of HBX-1 in the last twelve years. It was concluded that the changes in the method of charge preparation were responsible for decreases in the power of the explosive. A procedure for insuring reproducible performance of HBX-1 standards is recommended.

EXPLOSIONS RESEARCH DEPARTMENT
U. S. NAVAL ORDNANCE LABORATORY
White Oak, Silver Spring, Maryland

NOLTR 62-13 2 January 1962

COMPARISONS OF THE UNDERWATER POWER OF EXPLOSIVES IN SMALL CHARGES: VII. A STUDY OF FACTORS AFFECTING THE POWER OF HBX-1. (U)

The work described in this report is part of the continuing program of investigation of the underwater performance of explosive mixtures, under Task RUME-3-E-000/212-1/WF008-10-004, Problem Assignment No. 002.

HBX-1, used in small charges as a laboratory standard of comparison for new mixtures, showed an apparent decrease in underwater power with time. This work was initiated to study this change and to determine its cause.

W. D. COLEMAN
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Commander

C. J. Aronson

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By direction

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COMPARISONS OF THE UNDERWATER POWER OF EXPLOSIVES IN SMALL CHARGES: VII. A STUDY OF FACTORS AFFECTING THE POWER OF HBX-1 (U).

1. INTRODUCTION

The underwater power of new explosives is given a preliminary evaluation at the Naval Ordnance Laboratory by using UERL diaphragm gages to obtain a measure of shock wave energy and by using the first bubble period to obtain a measure of the total bubble energy. These parameters are given relative to those of pentolite, which is used as a standard. HBX-1, and occasionally HBX-3, charges are included in each experimental series to give a comparison of the new explosive with standard underwater loadings and to serve as secondary standards.

Since 1954 the relative shock wave and bubble energies of the HBX-1 charges fired in many series have been lower than the previous values. Some variation is to be expected in values obtained from series to series; however, the decrease shown by HBX-1 exceeded the normal differences obtained in programs prior to 1954. A study was made to examine some of the possible factors that could affect the efficiency of HBX-1 as an underwater explosive. This report discusses the data and the conclusions drawn.

2. BACKGROUND

2.1 Test Procedures. Briefly, the standard method for testing new explosives consists of firing one-pound charges of the experimental explosive and several weights of pentolite. The charges are fired at a fixed distance from UERL diaphragm gages [a]*. $(W_{Dd})_{pent}$, the weight of pentolite necessary to give the same diaphragm deformation as that produced by one pound of test explosive, is calculated from the experimental data [b]. The bubble energy of an explosive relative to pentolite, $(RBE)_{pent}$, is calculated as the ratio of the period constants cubed [b]. In general, the precision of these data is of the order of $\pm$ 0.03 for $(W_{Dd})_{pent}$ and $\pm$ 0.05 for $(RBE)_{pent}$ [c].

2.2 Apparent Decrease in Power of HBX-1. Values of $(W_{Dd})_{pent}$ and $(RBE)_{pent}$ for HBX-1 are shown in Figure 1 as a function of the date of firing. Values of W_{Dd} obtained during the period from July 1949 through October 1951 varied from 1.10 to 1.16. This range of values exceed that expected from the scatter obtained on a given series; a study of the variables showed that a seasonal effect was probably affecting the results [b].

*See List of References on Page 8 .

An apparent change in level of W_{Dd} is shown by the data obtained in October and November 1951. Several values ranging from 1.06 to 1.12 were obtained during the period from October 1951 through October 1955. Since most of these tests were done in cool months, it was believed, at the time, that the low results were due to the seasonal effect.

In March 1958, a very low value of W_{Dd}(1.03) was obtained. This result compared with earlier data showed conclusively that some uncontrolled variable was affecting the experimental results.

2.3 Preliminary Examination. Over the years, changes have been made in the recording equipment [c], the data reduction procedure*, and the barge on which the testing was done. No change has been made in the UERL diaphragm gages. Studies made in an effort to relate these changes with the apparent changes in W_{Dd} disclosed no correlation between the variations in the data and the experimental variables**.

A further examination of the data was then made. Deformations from all existing pentolite and HBX-1 charges were plotted as a function of time on a plot similar to Figure 1. There was a normal amount of scatter for the pentolite data but the average deformation was constant. The HBX-1 deformations showed small but definite decreases corresponding with the changes noted on the W_{Dd} plot. This indicated that the changes were due to variations in the HBX-1 charges. Subsequently, a review of charge variables was initiated.

3. CHARGE EFFECTS

3.1 Explosive Material Characteristics. A review of the characteristics of the components used in the preparation of HBX-1 was made. All met military specifications. The explosive components have shown different impact machine heights [d] from lot to lot. However, similar variation of impact height is shown by all explosives and is probably not significant.

3.2 Boostering. Small cast pentolite cylinders are used for boostering one pound charges. A check of all existing NOL data from one-pound explosives tests disclosed no evidence that there has been any change in the effectiveness of the boosters with time. Moreover, the pentolite, as evidenced from the standard charges, has not changed in underwater power.

*Most of the data reduction is now done on an IBM-704 instead of by hand.
**Most changes were checked at the time they were made to ascertain the absence of any new variables.

3.3 Charge Preparation. The data shown in Figure 1 and the data obtained on subsequent tests are listed in Table I and also shown in Figure 2; the method of charge preparation is noted for three groups of charges. The change in power of small HBX-1 charges with the method of charge preparation is apparent from this plot.

Information provided by persons directly concerned with the preparation of HBX-1 in its earliest stages revealed the following: From 1947 to 1951 explosive compositions were cast by an open-kettle method at Stump Neck, Maryland. Following relocation of the casting house at White Oak, Maryland, new, more refined techniques were gradually incorporated into the charge preparation. During this period of transition (1951-1954) when numerous improvements in casting methods were accomplished, no significant change in the density of the charge was noted.

Modernization of casting facilities continued, and in 1955 installation of equipment designed to prepare even better charges was completed. Vacuum casting [e] of various compositions became possible and higher densities were obtained by this means*. The dates of major changes in the method of charge preparation agreed with the dates on which the underwater power of HBX-1 decreased.

Data were obtained on three additional firing programs to verify that the method of charge preparation was the reason for the decrease in the power of HBX-1.

Two HBX-1 charges prepared by non-vacuum casting at White Oak in 1955 were fired in November 1959. The results ($W_{Dd} = 1.10$) were in good agreement with results obtained in 1955 and in 1957 from charges of the same casting house lot (CH1845). The data from charges prepared in 1959 by vacuum casting and fired at the same time were low ($W_{Dd} = 1.03$).

Vacuum and non-vacuum cast HBX-1 cylinders were prepared at White Oak and fired in September 1960 and in September 1961. On both tests the results from the non-vacuum cast charges were slightly higher than those from the vacuum cast charges.

4. CONCLUSIONS

A study of the variables connected with the underwater testing of small charges has shown that the method of charge preparation has a significant effect on the underwater performance of small charges of HBX-1. The "highest quality" charges, made by vacuum casting, produced the least amount of energy; those of "poorest quality", the greatest energy. This effect is important because new explosives are tested in small size prior to larger scale testing; large charges should not exhibit the same behavior.

*It was discovered some time later that some charges of HBX-1 had been cast within two percent of voidless density.

5. RECOMMENDATIONS

Standards for comparison of underwater explosive performance of one pound charges must be more carefully controlled than has inadvertently been done in the past. Continuation of HBX-1 as a secondary standard is recommended; the following procedure is suggested for assuring reproducible results:

(a) Impact sensitivity tests should be run on samples from each lot of explosive components included in HBX-1 before charge preparation begins for all explosive comparison programs. Additionally, this same information should be obtained on specimens of the finished charge.

(b) A quantitative analysis of specimens from all new shipments of Composition B for percentages of components.

(c) For all one pound explosives comparison diaphragm tests the "best" density attainable with non-vacuum casting methods should be requested. This density should be 1.70 gm/cc $\pm$ 0.01.

(d) A prototype X-ray of the best "standard" HBX-1 cylinder should be filed for comparison purposes. At least one X-ray should be taken from a charge picked at random from every casting house lot and compared to the standard for homogeneity, voids, etc.

(e) The HBX-1 standards should be provided with two sizes of booster; half of the charges with 30 gram pentolite boosters, and half with 100 gram pentolite boosters as a check on the adequacy of the booster.

(f) Data obtained on each firing program should be compared with the data reported herein to insure that the values of HBX-1 relative to pentolite remain essentially constant.

In addition, HBX-3 should be evaluated in all future explosive comparison programs. Thus, all experimental loadings would be compared simultaneously with a non-aluminized explosive (pentolite) and two mixtures of considerably different aluminum concentration.

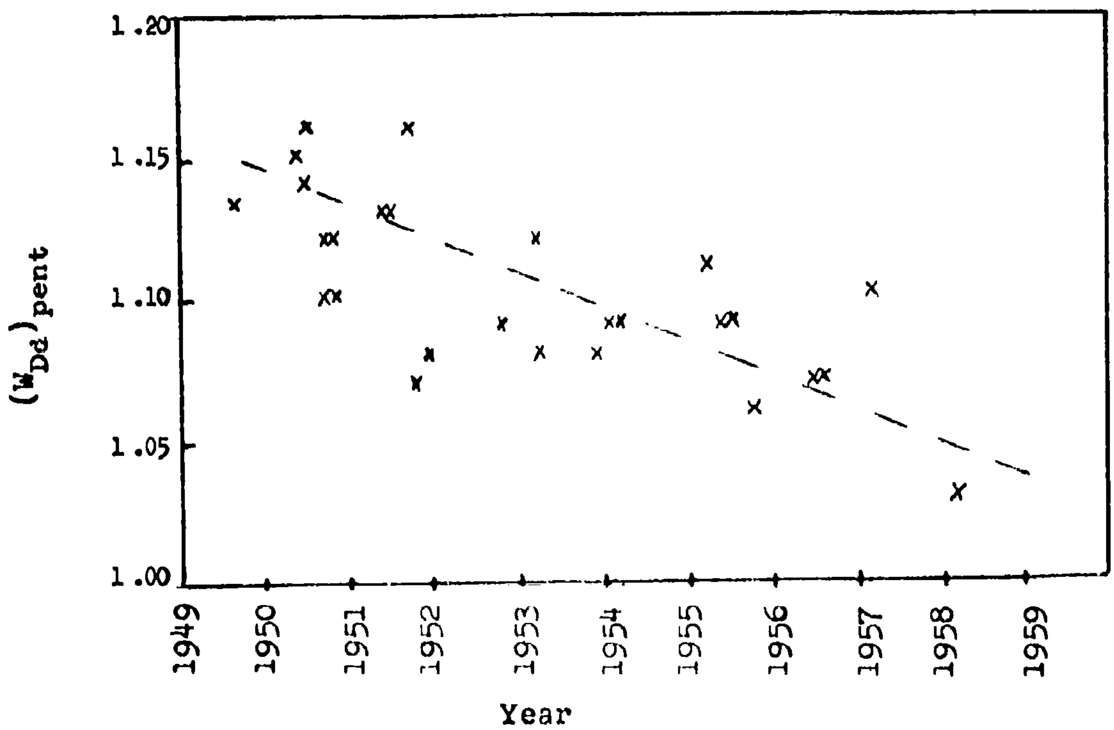

FIGURE 1 - APPARENT DECREASE IN THE SHOCK WAVE POWER OF HBX-1

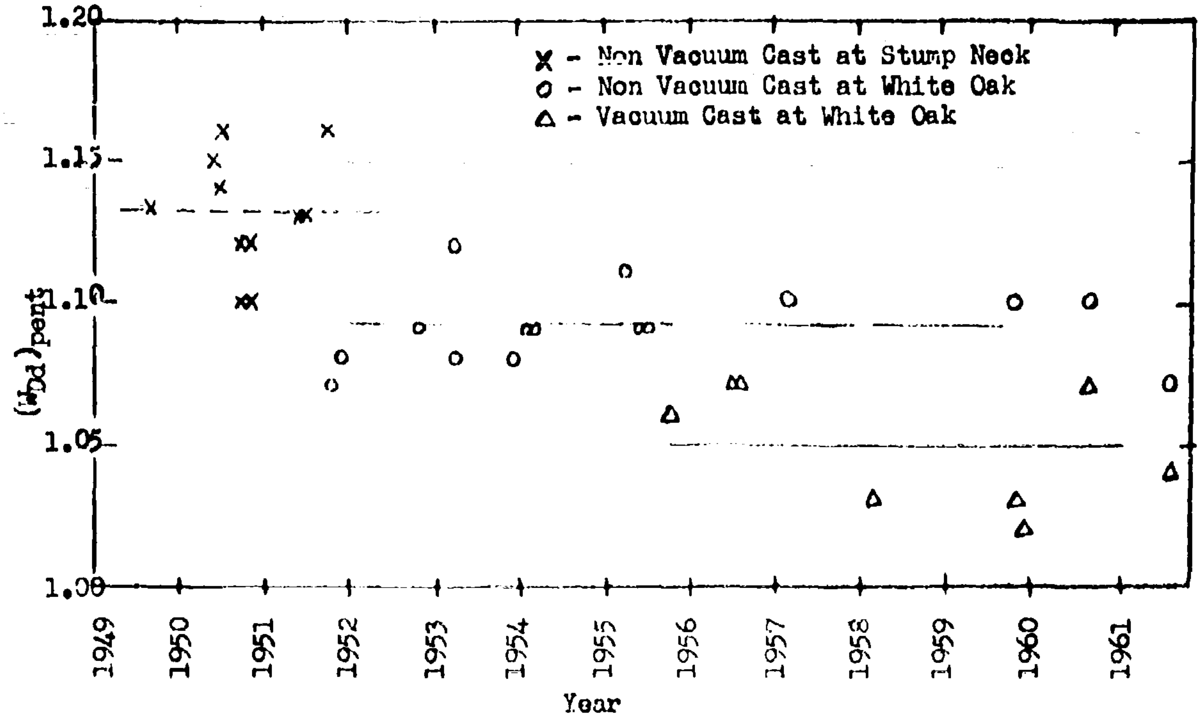

FIGURE 2 - THE EFFECT OF CHARGE PREPARATION ON THE SHOCK WAVE POWER OF SMALL HBX-1 CYLINDERS.

TABLE I

DIAPHRAGM GAUGE RESULTS FOR SMALL HBX-1 CYLINDERS

Shot No.	Program Fired Month	Year	Casting House No.	Charge Wt.* (gms)	Booster Wt. (gms)	Charge Density gm/cc)	Values Relative to Pentolite W_{Dd}	RBE	Product Index
				Non-Vacuum Cast at Stump Neck					
B52-123	Sept	1949		600	50	1.71	1.13	1.49	1.68
200-349	June	1950	357	355-454-600	30-50-100	1.71	1.15	1.46	1.68
350-389	July	1950	378	454	30-100	1.71	1.14	1.44	1.64
390-415	July	1950	378	227	30	1.71	1.16	1.45	1.68
459-502	Oct-Nov	1950	378	454	30	1.71	1.12	1.50	1.68
503-570	Oct-Nov	1950	411	454	30	1.71	1.10	1.47	1.62
571-626	Nov	1950	411	454	30	1.71	1.10	1.47	1.62
681-782	June	1951	449	405	50	1.71	1.13	1.47	1.66
798-857	July	1951	449	405	50	1.71	1.13	1.47	1.66
860-928	Oct	1951	592	500	50	1.69	1.16	1.46	1.69
				Non-Vacuum Cast at White Oak					
929-995	Nov	1951	595	400-600-800	50-100	1.71	1.07	1.46	1.56
1007-1028	Dec	1951	595	450	30-100	1.71	1.08	1.48	1.60
1049-1132	Nov	1952	824	450	30-100	1.71	1.09	1.41	1.54
1133-1247	Apr	1953	902	450	30-100	1.71	1.12	1.45	1.62
1133-1247	Apr	1953	1008	450	30-100	1.71	1.08	1.37	1.48
1345-1409	Dec	1953	1016	454	30-100	1.68	1.08	1.39	1.50
1422-1519	Feb	1954	1312	454	30-100	1.70	1.09	1.46	1.59
1523-1679	Mar	1954	1312	454	30-100	1.70	1.09	1.43	1.56
1807-1868	Apr	1955	1845	454	30-100	1.71	1.11	1.41	1.57
1872-1994	Jun-Jul	1955	1312	454	100	1.70	1.09	1.43	1.56
T180-197	Mar	1957	1845	454	30-100	1.71	1.10	1.50	1.65
2617-2661	Nov	1959	1845	450	30-100	1.71	1.10	1.38	1.52
2895-2962	Sept	1960	4382	490	56	1.69	1.10	1.47	1.62
2977-3087	Sept	1961	4783	454	30-100	1.72	1.07	1.48	1.58
				Vacuum Cast at White Oak					
1995-2124	Oct	1955	2005	454	30-100	1.73	1.06	1.55	1.64
2125-2472	Jul-Aug	1956	2241	454	30-100	1.71	1.07	1.45	1.55
2473-2563	Mar	1958	3228	454	30-100	1.73	1.03	1.47	1.51
2617-2661	Nov	1959	3972	454	30-100	1.74	1.03	1.38	1.42
2662-2766	Dec	1959	4076	454	30-100	1.73	1.02	1.34	1.37
2895-2962	Sept	1960	4388	490	56	1.72	1.07	1.45	1.55
2977-3087	Sept	1961	4874	454	100	1.74	1.04	1.44	1.48

* Includes booster weight.

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[b] "Comparisons of the Underwater Power of Explosives in the RDX/TNT/Aluminum System Using Small Charges", C. R. Niffenegger and E. Swift, Jr., NAVORD Report 2105, June 1951, Confidential

[c] "The Effect of Wax on Underwater Explosive Power and Impact Sensitivity, II. Five Compositions Containing High Percentages of Wax", M. A. Thiel and E. A. Christian, NAVORD Report 4477, October 1958, Confidential

[d] "Factors Affecting the Behavior of Explosives to Mechanical Shock", G. Svadeba, NAVORD Report 3592, 18 December 1953, Confidential

[e] "Capabilities of Explosive Loading Group of the Chemical Engineering Division (WE)", Carroll G. Misener, NAVORD Report 6873, September 1960, Unclassified

APPENDIX A

COMPARISON OF SMALL SPHERICAL AND CYLINDRICAL HBX-1 CHARGES

In 1960 a series of vacuum-cast HBX-1 spheres was fired. The one-pound spheres were boostered with 56-gm spherical pentolite boosters centrally located within the HBX-1 charge. These were compared with vacuum-cast cylinders boostered with 56 gm of pentolite in the usual manner* and fired in the same series. Both shock wave and bubble energy for the spheres were lower than the values obtained from the cylinders.

Charge Shape	Total Wt. (gm)	Approx. Density (gm/cc)	$(W_{Dd})_{pent}$	$(RBE)_{pent}$
Sphere	490	1.74	0.98	1.31
Cylinder	490	1.74	1.07	1.45

In computing the $(W_{Dd})_{pent}$ and $(RBE)_{pent}$ of the spherical HBX-1 charges, deformation versus weight curves and bubble period constants obtained from pentolite cylinders were used. To determine if the low values obtained were caused by a difference between any cylinders, a series of spherical pentolite charges was fired. The deformation versus weight curve obtained from pentolite spheres was considerably lower than the curve found from pentolite cylinders but the slopes of the curves were the same. The bubble period constants obtained from the spheres and cylinders were essentially the same.

The values obtained from the pentolite spheres were used to recalculate the $(W_{Dd})_{pent}$ and $(RBE)_{pent}$ of the HBX-1 spheres. The recalculated $(W_{Dd})_{pent}$ was almost identical with that measured from cylinders, i.e., 1.06. However, the $(RBE)_{pent}$ did not change appreciably, the final value being 1.33. The most plausible explanation for the sustained low RBE value is a combination of a shape effect and the lowering of bubble energy in vacuum-cast aluminized compositions observed in cylindrical charges. The

*The boosters were cylinders of pentolite inserted halfway into one end of the charge; each booster had a 1/2-inch deep hole to receive the detonator.

period constant of pentolite remained virtually unchanged, showing 4.41 and 4.42 for spherical and cylindrical charges, respectively. A significant difference was noted in the period constant for the HBX-1 vacuum-cast charges, i.e., 4.82 for the spheres as opposed to 4.94 for the cylinder.

The experimental work indicates that charge shape has a large effect upon the energy distribution of small charges. Past experience has shown that centrally initiated charges (~ 1-lb size) are more difficult to initiate reliably than end-initiated cylindrical charges. It is recommended that cylindrical charges (length to diameter ratio = 1/1) be used when possible. If other shapes are necessary for a test, a careful check of the charge output should be made.

APPENDIX B

RESULTS OF EXPERIMENTAL BOOSTER TESTS

One explanation for the decrease in HBX-1 shock wave power was the possibility of inadequate boostering of the charge. It was believed possible that with the highly compressed, vacuum-cast charges being prepared, a more powerful booster composition was needed to insure complete detonation.

Two tests were made to check this hypothesis: one involved using boosters of CH-6 which has approximately 7 percent higher shock wave energy than cast pentolite; the other was made by utilizing pressed (instead of cast) pentolite boosters.

Generally the overall performance of all cast charges boostered with CH-6 appeared to be slightly better than similar charges boostered with cast pentolite. However, the increase was so slight it fell within experimental error and it also failed to raise the relative shock wave energy of vacuum cast HBX-1 to the level of that displayed by the non-vacuum cast charges. HBX-1 cylinders using pressed pentolite boosters showed a decrease in efficiency. Results of these tests are as follows:

Type Booster	Total Wt. (gm)	Booster Wt. (gm)	$(W_{Dd})_{pent}$	$(RBE)_{pent}$
CH-6	490	56	1.08	1.46
Pentolite(cast)	490	56	1.07	1.45
Pentolite(pressed)	454	30-100	1.03	1.45

It appears that there is no valid reason to supplant the cast pentolite booster with either type tested here. The experiments discussed above show little or no enhancement of HBX-1 underwater explosion power with a change in the boostering system.

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